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TITLE: TUBING STRING HANGING APPARATUS

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TUBING STRING HANGING APPARATUS

FIELD OF THE INVENTION

This invention relates to an apparatus for rotatably hanging a tubing string in a wellhead, such as is commonly used in the oil industry.

BACKGROUND OF THE INVENTION

For a variety of different reasons, oil wells are often not perfectly vertical. Meandering or deviated well bores cause engagement of the sucker rod with the inner wall surface of the production tubing string causing wear to the tubing string through movement of the sucker rod. After a length of time, the sucker rod will either wear through the side of the tubing string or reduce it to a point of failure under load.

To reduce the effects of wear caused when a sucker rod comes into contact with the inner surface of the tubing string, others have developed tubing rotators which slowly rotate the tubing string about the sucker rod to more evenly distribute wear around the inside circumference of the tubing string.

Although such rotating devices have been proven to be an effective means for extending the life of a tubing string, their use has resulted in additional production difficulties. First, tubing rotators are typically threaded onto the upper end of the tubing string thereby making it necessary to "lift" the entire string in order to service the rotator. Secondly, in deviated wells the tubing string may be subjected to non-vertical loading resulting in excessive frictional wear between the tubing string and the sucker rod, particularly toward the bottom of the tubing string. Furthermore, existing rotator and tubing string structures are commonly prone to "blow-back"

wherein fluids are driven upwardly between the well casing and the tubing string resulting in leakage at the wellhead or loss of well control.

SUMMARY OF THE INVENTION

The invention therefore provides a tubing string hanger which overcomes the short falls of these prior devices through the incorporation of a structure which provides for full well control, accommodates vertical and non-vertical loading of the tubing string, and provides a means to hang the tubing string in the well casing while allowing a tubing rotator to be removed from the wellhead without having to pull or lift the tubing string from the well.

Accordingly, in one of its aspects the invention provides an apparatus for rotatably hanging a tubing string in a well casing having a wellhead, the apparatus comprising: a tubing hanger shell having means for engagement with said wellhead; a mandrel rotatably mounted within said tubing hanger shell, said mandrel having an upper end and a lower end, said lower end having engagement means for connection to said tubing string and said upper end engaging coupling means which connects said mandrel to a tubing rotator, said coupling means providing means to transfer rotational energy from said tubing rotator to said mandrel while allowing for the disengagement of said tubing rotator from said mandrel through the application of force, and through movement, in a direction parallel to the longitudinal axis of said tubing string; and bearing means disposed between said tubing hanger shell and said mandrel to facilitate in the rotation of said mandrel within said tubing hanger shell.

In another aspect, the present invention provides an apparatus for rotatably hanging a tubing string in a well casing having a wellhead, the apparatus comprising: a tubing hanger shell having means for engagement with said wellhead; a mandrel rotatably mounted within said tubing hanger shell, said mandrel having an internal tubing string pick-up thread and having an upper end and a lower end, said lower end having engagement means for connection to said tubing string; coupling means engaging said upper end of said mandrel and connecting said mandrel to a tubing rotator, said coupling means comprising a hollow sleeve threaded onto a rotor shaft of said tubing rotator and being received within said mandrel when said tubing rotator is connected to said mandrel, said hollow sleeve providing means to transfer rotational energy from said tubing rotator to said mandrel while allowing for the disengagement of said tubing rotator from said mandrel through the application of force, and through movement, in a direction parallel to the longitudinal axis of said tubing string; sealing means disposed between said tubing hanger shell and said wellhead, between said tubing hanger shell and said mandrel, and between said mandrel and said coupling means; and, bearing means disposed between said tubing hanger shell and said mandrel to facilitate in the rotation of said mandrel within said tubing hanger shell.

In still a further aspect the present invention provides an apparatus for rotatably hanging a tubing string in a well casing having a wellhead, the apparatus comprising: a tubing hanger shell for hanging said tubing string in said well casing, said tubing hanger shell having means for engagement with said wellhead; a mandrel rotatably mounted within said tubing hanger shell, said mandrel having an upper end and a lower end, said lower end having engagement means for connection to said tubing string and said upper end engaging coupling means for connection to a tubing rotator, said coupling means providing means to transfer rotational energy from said tubing rotator to said mandrel and allowing for the disengagement of said tubing rotator

from said mandrel without appreciable rotational movement; and, bearing means disposed between said tubing hanger shell and said mandrel to facilitate in the rotation of said mandrel within said tubing hanger shell.

In an alternate embodiment the present invention provides an apparatus for rotatably hanging a tubing string in a well casing having a wellhead, the apparatus comprising: a tubing hanger shell having means for engagement with said wellhead; a mandrel rotatably mounted within said tubing hanger shell, said mandrel having an upper end and a lower end, said lower end having engagement means for connection to said tubing string and said upper end having a series of longitudinally oriented splines that engage corresponding splines on a shaft of a tubing rotator connected thereto, said splines on said mandrel and on said tubing rotator providing means to transfer rotational energy from said tubing rotator to said mandrel while allowing for the disengagement of said tubing rotator from said mandrel through the application of force, and through movement, in a direction parallel to the longitudinal axis of said tubing string; and, bearing means disposed between said tubing hanger shell and said mandrel to facilitate in the rotational movement of said mandrel within said tubing hanger shell.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings which show the preferred embodiments of the present invention in which:

Figure 1 is a side elevational view in longitudinal section of a tubing string hanger device in accordance with the present invention.

Figure 2 is a sectional view of the device in Figure 1 taken along the line 2-2.

Figure 3 is a side sectional view of the coupling means shown in Figure 1.

Figure 4 is a side elevational view in longitudinal section of a tubing string hanger device in accordance with an alternate embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figures 1 and 2, a tubing string hanger pursuant to the present invention is generally noted by the numeral 1. The hanger apparatus 1 is comprised primarily of a tubing hanger shell 2 and a mandrel 5. As shown in Figure 1, tubing shell hanger 2 has means 3 for engagement with a wellhead 4 of a well casing 32.

Mandrel 5 is rotatably mounted within tubing hanger shell 2 and has an upper end 9 and a bottom or lower end 10. Lower end 10 of mandrel 5 includes engagement means for connecting mandrel 5 to a tubing string 7. On its upper end 9, mandrel 5 engages a coupling means 8 which connects mandrel 5 to a tubing rotator 11. Coupling means 8 provides a means to transfer rotational energy from tubing rotator 11 to mandrel 5, and accordingly to tubing string 7. Coupling means 8 also allows for the disengagement or removal of tubing rotator 11 from mandrel 5, and the top of wellhead 4, without the need to pull or remove either mandrel 5 or tubing string 7 from the well. Through the use of hanger 1, tubing rotator 11 can also be removed without appreciable rotational movement of mandrel 5 and tubing string 7.

Referring to Figure 1, hanger 1 includes bearing means 12 disposed between tubing hanger shell 2 and mandrel 5. Bearing means 12 facilitates in the rotation of mandrel 5 within tubing hanger shell 2 through a reduction in the friction between the respective parts. Bearing means 12 comprises both thrust bearings 13 and radial bearings 14. Thrust bearings 13 are situated between a lower shoulder 15 on tubing hanger shell 2 and an upper shoulder 16 on mandrel 5 such that the vertical loading of mandrel 5 is carried on thrust bearing 13 and transferred to tubing hanger shell 2.

As depicted in Figure 1, radial bearings 14 are preferably positioned above thrust bearings 13. Radial bearings 14 facilitate in the rotational movement of mandrel 5 within tubing hanger shell 2 in deviated well situations, where mandrel 5 may be subjected to non-vertical loading.

In order to "hang" tubing string 7 within wellhead 4, means 3 for engagement with wellhead 4 preferably comprises an inwardly tapered exterior surface 17 on tubing hanger shell 2. Tapered surface 17 frictionally engages an inwardly tapered shoulder 18 on the interior surface of wellhead 4. Since the diameter of tubing hanger shell 2 is greater than the internal diameter of wellhead 4, tubing hanger shell 2 acts as a plug that holds mandrel 5, and consequentially tubing string 7, in position.

Though the vertical loading of mandrel 5, tubing hanger shell 2 is effectively seated against shoulder 18 and wellhead 4 forming a tight friction-fit. As is shown in Figure 1, a series of sealing means 19, disposed between tubing hanger shell 2 and wellhead 4, between tubing hanger shell 2 and mandrel 5, and between mandrel 5 and coupling means 8, assist in preventing the leakage of fluid past hanger 1. In the preferred embodiment, sealing means 19 comprise O-ring seals.

To assist in the incorporation of mandrel 5 into a standard oil well environment

employing a typical tubing string, engagement means 6 on the bottom of mandrel 5 preferably comprises a threaded portion for accepting a correspondingly threaded portion on tubing string 7. That is, in the preferred embodiment mandrel 5 would simply be threaded onto the upper end of the tubing string 7. In addition, to assist in the removal of tubing string 7 from wellhead 4 (ie. "pulling" the well), mandrel 5 preferably includes an internal tubing string pick-up thread 20. Pick-up thread 20 allows for mandrel 5 and tubing string 7 to be lifted from wellhead 4 through the use of a crane or lifting device connected to mandrel 5 by threading a shaft or pipe into pick-up threads 20.

To hold mandrel 5 within tubing hanger shell 2 retaining means 21 is utilized. Retaining means 21 would typically comprise a retaining nut that is threaded onto the top portion of tubing hanger shell 2. As shown in Figure 1, the upper portion of tubing hanger shell 2 contains internal threads 22. Retaining nut 21 has corresponding external threads 23 such that it may be screwed downwardly into tubing hanger shell 2. When retaining nut 21 is threaded into tubing hanger shell 2, its lower surface 24 is positioned next to face 25 of mandrel 5 such that mandrel 5 is effectively held within tubing hanger shell 2 yet is still able to rotate freely. Furthermore, through adding torque to retaining nut 21 mandrel 5 is closely held within tubing hanger shell 2 regardless of the vertical or radial load supplied by tubing string 7. This structure also allows mandrel 5 to rotate freely in either direction while secured within hanger shell 2.

Retaining nut 21 has a further function in that it contains a longitudinally oriented keyway 33 that aligns with a corresponding keyway 34 on mandrel 5, as shown in Figure 2. When retaining nut 21 is screwed into position into tubing hanger shell 2, keyways 33 and 34 align such that a key 35 may be inserted therein to prevent rotation of mandrel 5. In normal operation key 35 would not be used and mandrel

5 would be free to rotate. However, when it becomes necessary to lift the tubing string from the well, key 35 is inserted into aligned keyways 33 and 34 so that mandrel 5 is prevented from rotating. A shaft or pipe may then be threaded into pick-up threads 20 and the tubing string lifted from the well. Preferably more than one set of keyways 33 and 34 and more than one key 35 would be utilized. In Figure 2, two such keyways and keys are shown.

In the operation of the preferred embodiment, mandrel 5 is screwed onto the top of tubing string 7 with tubing string 7 being positioned in the well casing. Tapered exterior surface 17 of tubing hanger shell 2 bears against inwardly tapered shoulder 18 of wellhead 4 to hold tubing hanger shell 2, and hence mandrel 5 and tubing string 7, securely within the wellhead. Retaining nut 21 secures mandrel 5 within tubing hanger shell 2. Tubing rotator 11 is then positioned over wellhead 4 such that coupling means 8 connects mandrel 5 to tubing rotator 11. Bolts 30 are typically used to hold tubing rotator 11 in place and a seal 31 helps to prevent leakage from between the rotator and the wellhead.

It will be appreciated that in order for tubing rotator 11 to be removed from wellhead 4 without the need to lift tubing string 7 from the well, coupling means 8 must allow for the disengagement of tubing rotator 11 without appreciable rotational movement. Where tubing rotator 11 has been threaded onto mandrel 5, to remove the rotator it is necessary to back-off or unscrew the rotator shaft in a direction opposite to which it was attached and unthread it from the mandrel. Subjecting mandrel 5 (and hence tubing string 7) to significant rotational movement in this "unthreading" direction could result in the loosening or undoing of threaded connections in the tubing string and loss of the string into the well.

As shown in Figures 1 and 3, coupling means 8 comprises a hollow sleeve 36 having

external drive means 37 that engage mandrel 5. The interior surface of sleeve 36 contains threads 38 such that sleeve 36 may be threaded onto a rotor shaft 29 of rotator 11. In the preferred embodiment, drive means 37 comprises outwardly projecting splines 28 that engage corresponding spines 27 on mandrel 5.

Splines 27 and 28 are longitudinally oriented such that tubing rotator 11, with sleeve 36 threaded onto the lower end of shaft 29, may be connected to mandrel 5 through insertion of rotator shaft 29 into the upper end 9 of mandrel 5; splines 28 being received in the openings between splines 27. In this fashion, splines 28 bear against splines 27 upon rotation of rotator shaft 29 causing mandrel 5, and hence tubing string 7, to rotate. To facilitate the insertion of shaft 29 into mandrel 5, splines 27 and 28 are preferably of an involute configuration.

This structure allows for the rotational movement of mandrel 5 while still permitting the removal of tubing rotator 11 through lifting it off the wellhead without significant rotational movement and without running the risk of loosening threaded joints in the tubing string. There is therefore no need to lift the entire tubing string. While in most cases the removal or disengagement of tubing rotator 11 from mandrel 5 will require the application of a lifting force, and through motion, in an approximately vertical direction, it will be appreciated that in installations where a well casing is not vertical, tubing rotator 11 will be disengaged through the application of force, and through movement, in a direction parallel to the longitudinal axis of mandrel 5 and tubing string 7.

Although it may occasionally be necessary to slightly back-off tubing rotator 11 to disengage splines 28 from splines 27 when removing rotator 11 from the wellhead, the structure of splines 27 and 28 permit disengagement of rotator 11 without appreciable rotational movement. Any such backing-off that may be required will

involve only a very slight reversing of rotator shaft 29 to disengage any significant frictional contact that may exist between splines 27 and 28. The structure of splines 27 and 28 enable them to readily slide past each other when removing rotator 11. Accordingly, there is no risk of loosening any threaded connections in the tubing string.

In the alternate embodiment of the invention shown in Figure 4, splines 28 project outwardly from the exterior surface of rotor shaft 29. Splines 28 engage splines 27 of mandrel 5 to permit rotation of mandrel 5, and to allow for the removal of tubing rotator 11, in the same manner as described above. The primary difference in this embodiment is that there is no requirement for sleeve 36 as splines 28 are formed directly on shaft 29.

It is to be understood that what has been described are the preferred embodiments of the invention and that it is possible to make variations to these embodiments while staying within the broad scope of the invention. Some of these variations have been discussed while others will be readily apparent to those skilled in the art. For example, while reference has been made to the use of splines 27 and 28, it will be appreciated that coupling means 8 could include other forms of connection means performing a similar function, including a pin and J-channel structure.